Reliability of prompt γ-ray intensities for the measurement of neutron capture cross sections

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Neutron capture cross sections of long-lived fission products (LLFP) are needed for a nuclear transmutation technology. Determining the cross sections by using the activation method, if produced nuclei have too long half-lives or are stable, it is difficult. A measuring method by detecting prompt γ-rays (the prompt-γ method) is expected to solve this problem.

It is considered that the comparison with the activation method, which has reliable actual results, can verify the new method. Therefore the cross sections were measured by using the prompt-γ method and the activation method, respectively.

Thermal neutron irradiations were carried out by the B-4 neutron guide facility at the Kyoto University Reactor. Since the (n, γ) reactions of ^{23}Na, ^{27}Al, ^{51}V, ^{55}Mn, ^{64}Ni, ^{65}Cu, ^{141}Pr, ^{186}W and ^{197}Au make the nuclei which half-lives are enough short to measure, the reactions were measured with three 22, 38 and 90% HPGe detectors and a 90% GAMMA-X HPGe detector. The distance from a sample to each detector was 5 cm. A box and plates made of a lithium fluoride were used for shielding from neutrons. The irradiating periods were about 0.4$\sim$3 h.

For nine reactions, the ratios of measured cross section values by the prompt-γ method to those by used the activation method were analyzed. The ratios of ^{65}Cu and ^{186}W are -10% and -25% away from the others, respectively. Those of the other seven reactions were in agreement within 5%. It is clearly seen that the ratios are lower systematically than 1.0 (σ_{prompt}=σ_{decay}). It is considered the reason is inaccuracy of the each emission probability of prompt γ-rays.

We have concluded that the prompt-γ method cannot determine (n, γ) cross section within 10% because precise emission probabilities are not well known. Using more precise emission probabilities of γ-rays following β-decay, those of prompt γ-rays can be determined also.

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